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Age in Relation to Worker Compensation Costs in the Construction Industry

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Abstract

Background—A better understanding of how workers' compensation (WC) costs are affected by an aging US workforce is needed, especially for physically demanding industries, such as construction.

Methods—The relationship between age and injury type on claim costs was evaluated using a database of 107,064 Colorado WC claims filed between 1998 and 2008 among construction workers.

Results—Mean WC costs increased with increasing age for total cost ($P < 0.0001$), medical costs ($P < 0.0001$), and indemnity costs ($P < 0.0001$). For each one-year increase in age, indemnity, and medical costs increased by 3.5% and 1.1%, respectively. For specific injury types, such as strains and contusions, the association between age and indemnity costs was higher among claimants aged ≥65 compared to claimants aged 18–24.

Conclusions—Our findings suggest that specific injury types may be partially responsible for the higher indemnity costs among older construction workers, compared with their younger coworkers.

Keywords

aging workforce; construction industry; workers' compensation; older workers; occupational injury

INTRODUCTION

The proportion of workers 55 years of age and older will grow to nearly a quarter of the United States (US) labor force by 2018, a 43% increase from 2008 [Toossi, 2009]. As aging workers remain on the job longer, understanding the health and safety needs of an aging workforce will be critical. This will be especially true for physically demanding jobs, such as those in the construction trades, where older workers may be at higher risk of injury and illness. The injuries and illnesses sustained by workers in the construction industry often

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result in a significant financial burden for the worker, industry and society as a whole [Dong et al., 2007; Waehrer et al., 2007a].

Construction workers have higher rates of injuries than workers in other industries [U.S. Bureau of Labor Statistics, 2009] and the average total cost of their injuries is significantly greater. In the US, the estimated average total cost of construction-related injury was $27,000, with a greater proportion of the total costs related to indirect costs (e.g., wage loss) rather than direct costs (e.g., medical costs), compared to $15,000 across all industries in 2002 [Waehrer et al., 2007a]. Waehrer et al. [2007b] esti-mated that $13 billion is spent annually in the US on workers' compensation (WC) costs in the construction industry, making it one of the most expensive industries to insure. According to the National Compensation Survey in 2011, the construction industry spent on average, $1.32 per hour worked on WC. This is triple the cost spent 2 Schwatka et al. across all industries ($0.44 per hour worked) [U.S. Bureau of Labor Statistics, 2011].

Given the high cost of work-related injuries and illnesses in the construction industry, it is important to understand what factors contribute to these costs. Older construction workers (>55 years of age) are responsible for a disproportionate risk of work-related health issues [NORA Construction Sector Council, 2008; Dong et al., 2011; Schwatka et al., 2012], but their contribution to the total cost of injuries and illnesses has yet to be quantified. Previous research has either limited their discussion to specific construction trades, types of injuries or WC claims [e.g., Lipscomb et al., 2003; Friedman and Forst, 2009; Lipscomb et al., 2009]. As construction workers age, they will likely experience physical limitations and co-morbidities [Welch et al., 2008; Dong et al., 2011]. These vulnerabilities will adversely affect their ability to perform physically demanding work in the construction industry, leaving them more susceptible to injuries such as musculoskeletal disorders (MSDs), fractures and contusions [Maertens et al., 2012; Schwatka et al., 2012]. Despite these findings, older worker age does not appear to be associated with higher injury rates [Rogers and Wiatrowski, 2005; Schoenfisch et al., 2010; Restrepo and Shuford, 2011].

Older construction workers, however, may be more likely to experience severe-type injuries compared with younger construction workers. This trend may result in higher indemnity, rather than medical costs, as older construction worker's injuries may require more days away from work and may result in disabilities and physical limitations [Choi, 2009; Schwatka et al., 2012]. Although injuries among older construction workers may result in greater indemnity costs, it is not clear whether they may not reflect a greater total cost per claim as compared to their younger coworkers. In the present study, we performed a comprehensive investigation of the association between worker age, injury type and WC costs (overall and by cost type) among claimants employed in the construction industry. Over 100,000 construction WC claims filed in the state of Colorado between 1998 and 2008 were analyzed in order to test the hypothesis that the positive association between age and WC cost would differ by cost type (e.g., total, medical, and indemnity costs), and that the relationship between injury type and cost would vary by age.

METHODS

Workers' Compensation Database

A database of closed WC claims filed between June 30, 1998 and June 30, 2008 by construction workers in Colorado was created using data from the one of state's largest WC insurers, Pinnacol Assurance. A description of the Colorado WC system can be found in previously published articles [Douphrate et al., 2006; Douphrate et al., 2009a]. The claims represented approximately 80% of all construction company policyholders in the state of Colorado, as referenced by National Council on Compensation Insurance codes [Actuarial from Pinnacol Assurance, oral communication, 2010]. Using the US Census's Statistics of US Businesses, we estimated the Pinnacol dataset represents about 14,000 construction establishments and about 124,000 construction workers per year in Colorado [Statistics of U.S. Businesses, 1998–2008].

This study includes WC claims that are "closed" rather than claims that are still "open" and actively incurring costs related to the injury. In order to capture the claims at a time in which the majority of costs have been incurred, a 24-month period following the initial date of claim filing was chosen. This timeframe was chosen because >99% of claim costs occur during this time span [Actuary from Pinnacol Assurance, oral communication, 2010]. For example, for a claim that was submitted on June 30, 1998, all costs incurred through June 30, 2000 would be included for that claim. Thus, the dataset includes claim costs incurred from June 30, 2000 to June 30, 2010 (see Fig. 1). The Institutional Review Board (IRB) at Colorado State University declared in a letter that the project was exempt from IRB since individuals within the dataset were not identifiable. Thus, informed consent was not necessary.

Statistical Analyses

The following variables were used in these analyses: claimant age at time of first report of injury (year), injury type (strain, contusion, laceration and other), total cost ($), medical cost ($) indemnity cost ($), and claim type (medical-only cost claims or medical plus indemnity cost claims). The total cost of a claim included all costs associated with the claim (medical, indemnity, and other expenses). Medical expenses included all healthcare related services and products (e.g., physician visits, treatment, rehabilitation, diagnostic testing, adaptive equipment, and prescription medications). Indemnity expenses included wage-replacement, disability, impairment, and death benefits. Other expenses included ancillary costs such as legal fees. All cost variables were adjusted for infiation to 2010 US dollars by using the Consumer Price Index (CPI-U) [Chairman of the Council of Economic Advisors: United States Government Printing Office, 2012]. Although medical costs generally increase at a greater rate than the overall infiation rate, adjusting the medical costs by the specific medical CPI did not result in meaningful changes in the results. The only change observed was an increase in mean medical cost by an approximate $400 increase for all age groups. Thus, all results are presented with adjustment using CPI-U.

Descriptive statistics were generated for all variables in the study. Age of the claimant was evaluated as a continuous (≥18 years) and categorical variable (18–24, 25–34, 35–44, 45–

54, 55–64, ≥65 years). More than 60% of all the claims were due to the three most frequent types of injuries (strains, contusions, and lacerations). Thus, type of injury was collapsed into four categories, “other” being the forth category. The number of claims, type of injury frequency and mean cost of a claim (total, medical, and indemnity) were determined for each age group. For all inferential statistical analyses, the cost variables were logtransformed in order to correct for non-normality. Analyses of variance (ANOVA) were used to evaluate whether there were statistically significant differences in the mean cost of claim (total, medical, and indemnity) across age groups. Bonferroni adjusted multiple pairwise compari-sons were conducted to determine which age groups had significant mean differences. Pearson correlation coefficients were obtained in order to determine if there was a significant linear trend between age (years) and cost (total, medical, and indemnity).

Linear regression analyses were used to evaluate the effect of the explanatory variable (i.e., claimant years of age) on the outcome variables (i.e., total cost, medical cost, and indemnity cost) overall, and stratified by injury type. Each cost variable was assessed in separate simple linear regression models with age of claimant as the predictor. Multiple linear regression analyses were used to evaluate the potential modification of the age of claimant on the indemnity cost of different types of injuries. The final multiple regression model was run without the intercept in the final model in order to determine specific slope estimates for each type of injury by claimant age group. Statistical computing was conducted using SAS PC software version 9.2 (SAS Institute, Inc., Cary, NC). All *P*-values were two-sided and considered statistically significant if less than 0.05.

RESULTS

In our dataset of 107,065 WC claims among construction workers in Colorado, the mean claimant age was 34 years (SD = 11) and the median was 33 years (IQR = 26–43). The majority of injured workers who filed a claim were male (97%). Workers under the age of 45 filed approximately 80% of the WC claims. After adjusting all costs to 2010 dollars, the total cost of the 107,064 claims was $931,234,994. The total medical cost and total indemnity cost were $408,613,710 and $461,084,685, respectively.

Of all claims filed, 23% (n = 24,846) were WC claims with medical plus indemnity costs and 77% (n = 82,219) were WC claims with medical only costs. Claimants over the age of 65 filed more medical plus indemnity-type claims (34%) than claimants between the age of 18 and 24 years of age (18%) ($\chi^2 = 91.68$, $P < 0.0001$). When the costs ($) of the claim types were compared, claimants over the age of 65 had a higher per-centage of indemnity costs (e.g., 63% of the total costs were due to indemnity costs), compared to claimants aged 18–24 years (e.g., 51% of the total costs were due to indemnity costs) (Table I).

The majority of claims were related to strains (27%), contusions (21%), and lacerations (17%). Other injuries included: foreign body (7.5%), sprain (6.6%), puncture (6.3%), fracture (3.6%), crushing (1.5%) burn (1.47%), and all other injuries (8.6%). The other category included injuries that represented <1% of the claims and “all other” injuries, as defined by the insurer who provided the database of claims. Strains were the most common type of injury among all age groups except for the oldest age group, ≥65, where strains and contusions occurred at similar frequencies, 26% and 27% of all claims, respectively. Lacerations occurred more frequently among younger age groups (18–24 years) compared with older age groups (≥65 years), accounting for 21% and 12% of all injuries, respectively. There were no meaningful differences between age groups for the other types of injuries (data not shown). The mean cost of a claim related to each type of injury (strains, contusions, lacerations, other) generally increased with increasing age group (see Table II) with the greatest proportion of total costs attributed to indemnity expenses. For example, the proportion of the total WC costs attributable to the indemnity costs for a strain type of injury were 59% for claimants ≥65, compared to 52% for claimants 18–24 years. The proportion of the total WC costs attributable to the medical cost of a strain type of injury was and 35% for claimants ≥65 years and 39% for those 18–24 years, respectively (data not shown).

Claimant age (years) and WC costs had a small, but statistically significant correlation with total costs ($r = 0.07$, $P < 0.0001$), medical costs ($r = 0.05$, $P < 0.0001$), and indemnity costs ($r = 0.10$, $P < 0.0001$). Mean costs (total, medical, and indemnity) of a claim increased with increasing age group, with one exception (see Table I). Mean medical cost per claim increased up to the 55- to 64-year age group then slightly decreased for the ≥65-year age group. The differences in mean cost by age group were statistically significant: total cost ($F_{5,107059} = 123.99$, $P < 0.0001$), medical costs ($F_{5,107059} = 56.43$, $P < 0.0001$), and indemnity costs ($F_{5,107059} = 236.86$, $P < 0.0001$).

A priori multiple pairwise comparisons using a Bonferroni-adjusted alpha level of 0.003 per test (0.05/15) was used to evaluate mean costs between claimant age groups (Table III).

There were statistically non-significant differences in mean total cost between claimants 35–44 years of age and those ≥45 years of age [e.g., 45–54 ($P = 0.02$), 55–64 ($P = 0.02$), ≥65 years ($P = 0.33$)]. In other words, total costs increased with increasing age category until ≥35 years of age when total costs plateaued. A similar pattern was observed for medical costs. In terms of indemnity costs, there were statistically non-significant differences in mean indemnity costs between claimants 45–54 years of age and those ≥55 years of age [e.g., 55–64 ($P = 1.00$) and 65+ ($P = 0.014$)]. In other words, indemnity costs increased with increasing age category until ≥45 years of age when indemnity costs plateaued.

Simple linear regression analyses were used to further evaluate the relationship between claimant age, type of injury, and WC costs. The first step in assessing this relationship was to evaluate age of claimant and cost in univariate models (see Table IV). When age of claimant was included in the model as a continuous variable, the strongest association was observed between claimant age and indemnity costs. There was a 3.51% increase in the indemnity cost of a claim for each 1-year increase in the age of a claimant. In contrast, there was a smaller 1.11% increase in the medical cost of a claim for each 1-year increase in the age of a claimant. We also included age in the model as a categorical variable, because the ANOVA results indicated that age might not be a linear function of cost. Compared to claimant's aged 18–24, all other age groups exhibited a greater increase in cost, especially for indemnity costs. For example, a claimant ≥65 years had a 46% higher medical cost than a claimant aged 18–24 but a 372% higher indemnity cost. In summary, we observed the similar relationships between age and cost by type, regardless of whether age was included as a continuous or categorical variable in the linear models.

To further explore the relationship between age and indemnity costs, we conducted linear regression analyses with type of injury as one of the predictors (see Table V). In the univariate model, a strain type of injury was more costly than the other three types of injuries. For example, a contusion type of injury was 46% less costly than a strain type of injury.

In multiple linear regression analyses by claimant age, we observed stronger associations for strains, contusions, and other types of injuries with indemnity cost as age increased (all P for trends <0.05), with the strongest associations observed among claimants ≥65 years. We did not observe evidence for modification by age on the association between laceration type of injury and indemnity cost. The final interaction model for injury type by age group explained 3.1% of the variance in indemnity cost (Table V).

DISCUSSION

Using a large WC database that was representative of approximately 80% of Colorado construction industry WC policyholders, we evaluated the relationship between age, injury type and costs. The mean total cost of a claim filed by workers 65 years and older was about three times the cost of a claim filed by workers aged 18–24. Yet, workers under the age of 45 filed 80% of the claims. Linear regression analyses revealed that the increase in costs among older workers was driven by increases in indemnity costs, rather than medical costs. We also reported that the indemnity costs associated with specific injuries (e.g., strains and contusions) increased along with age of the claimant. These results suggest a major financial burden, particularly due to indemnity costs (i.e., lost days at work, disabilities, and physical limitations) among the companies that insure workers and the WC insurance agency that will incur among the aging construction workforce.

Our findings indicated that overall there were statistically significant differences by mean WC costs regardless of cost type by increasing age group (18–24, 25– 34, …, ≥65 years). For individual age group comparisons, statistically significant differences in mean total costs were observed among increasing age groups up to age 35, while mean costs did not differ significantly between older age groups (35–44, 45–54, 55–64, and ≥65 years). Medical costs plateaued at 35–44 years of age but indemnity costs plateaued at 45–54 years of age. Our results suggest that how we define "older age," in terms of a subset of the workforce most susceptible to injury, may need to be adjusted downward. Our results also high-light the importance of evaluating cost type, rather than just total cost when describing relationships between age and cost.

Our findings support previous research demonstrating that worker age was positively associated with WC costs, although the age at which costs begin to plateau differs across studies. In a study of over 20,000 WC claims among Illinois construction workers' between 2000 and 2005, the mean total cost of compensation peaked for workers aged 55–64 and then declined slightly for workers over the age of 65 [Friedman and Forst, 2009]. Similar findings were reported by Waehrer et al.'s [2007a] study of construction injuries (N = 162,371 injuries) where mean total cost of injuries and illnesses requiring days away from work peaked at ages 45–54 and declined for workers over the age of 55. Their database of occupational injuries, however, came from the Survey of Occupational Injuries and Illnesses (SOII) (2002 Annual Survey) collected by the Bureau of Labor Statistics (BLS) and only represents construction companies with ten or more employees. Of all construction establishments in the US, 79% have less than ten employees, and these establishments make up 24% of the construction workforce [Center for Construction Research and Training, 2008]. These previous studies were either smaller in size [Friedman and Forst, 2009] or had an occupational injury database that was not representative of the entire construction industry [Waehrer et al., 2007a]. Our data, while only representative of the Colorado construction industry, suggest that that the age at which WC costs plateau may be younger than previously reported. A recent report from the National Council on Compensation Insurers found similar trends [Restrepo and Shuford, 2011].

We determined that strains and contusions were more common among construction workers and that age modified the association between injury type and indemnity cost. Our top three frequently occurring types of injuries (strains, contusions, and lacerations) were also cited as the top construction industry related injuries treated in hospital emergency rooms in a recent study using National Electronic Injury Surveillance-Work (NEISS-Work) database [Schoenfisch et al., 2010]. The results of the present study suggest that the divergence in indemnity cost among older and younger workers becomes greater as injury severity increases.

While the present study determined that older workers filed a small percentage of claims related to minor injuries (i.e., lacerations), it is possible that older workers selectively report the most serious of injuries. Older workers may shy away from the negative attention related to injury reporting as they already face the stigma associated with being part an aging workforce. There may be additional fears related to being singled out for their "carelessness" or "unsafe acts" that could lead to retaliation. Additionally, throughout their careers, older workers may have had unpleasant experiences with the WC system and chose not to report minor injuries in order to avoid further frustrations. Despite these issues, older and younger workers who filed a claim for minor injuries had similar indemnity costs.

We reported that indemnity costs, rather than medical costs were driving the higher WC costs among older construction workers. Our findings supports previous research findings that indicate more lost workdays [Lowery et al., 1998; Horwitz and McCall, 2004; Kucera et al., 2009] and increased disability [Courtney et al., 2002; Arndt et al., 2005; Welch et al., 2010], and thus, higher indemnity costs among aging construction workers. Lowery et al. [1998] determined that rate of lost work time among construction workers at a large Owner Controlled Insurance Program site was greatest among workers over the age of 50. Kucera et al. [2009] found that among workers 45 years and older were 60% more likely to have a claim with delayed return to work (>90 days away after injury), compared to workers less than 30 years of age. A study that utilized WC claims from the Oregon construction industry found that the temporary total disability compensated days was greatest among workers 46 and 55 years of age [Horwitz and McCall, 2004]. Our findings not only support previous findings, but also provide novel quantitative data on the increased financial costs associated with lost work time and disability among older construction workers.

Our study supports previous research that indicates injuries to the musculoskeletal system (e.g., strains) are of particular concern for aging construction workers [de Zwart et al., 1999; Welch et al., 2008; Hoonakker and van Duivenbooden, 2010; Welch et al., 2010]. In our database, approximately 50% of all strain injuries were to the spine/back/lower trunk among all age groups. Overexertions of the back are a major source of pain and injury among older construction workers [Welch et al., 2008; Hoonakker and van Duivenbooden, 2010]. A significant amount of lost work time, delayed return to work, and disability from back injuries among aging construction workers has been reported among carpenters in Washington state [Lipscomb et al., 2008]. Lipscomb et al. [2009] reported that payment rates increased with age but the source of payments were not reported (i.e., medical vs. indemnity payments). Our results are consistent with these previous results, but also contribute new information about the actual dollar amount associated with strain-type injuries and how the association with indemnity costs increase with in-creasing age of the claimant.

Strengths and Limitations

The utility of WC data has been demonstrated by many studies that have characterized work related injuries in terms of their cost, type, and cause in a variety of occu-pations [Hofmann et al., 2006; Friedman and Forst, 2009]. Colorado WC data, specifically, have been used to identify costs, characteristics, and contributing factors of agricultural injuries and illnesses [Douphrate et al., 2006, 2009a,b]. Unlike other databases of occupational injuries and illnesses, WC data are not limited to establishments with less than ten employees (BLS SOII) and workers who were treated in hospital emergency rooms (NEISS-Work) and includes incurred costs related to medical treatment and compensation. This allows for greater generalizability of the results obtained from WC data analyses that can then be used to inform policies aimed at reducing injury and illness in the workplace.

The data analyzed in the present study were originally created to manage insurance payments and thus the cost variables are relatively accurate and complete for all claims. The consistency of medical fees during the 10-year period from which these data were derived is unclear as fee schedule for medical care may have varied but these possible changes were likely to be small and thus would not have infiuenced our main findings. We also did not have information on the workers who filed the claim, which hindered our ability to adjust for potential confounders, such as race/ethnicity, body mass index, years of experience and other personal and occupational factors. Similar to the majority of studies that use WC claims data, information related to the incumbent workforce was not available, such as the number of hours worked and wages or salaries earned by each claimant. It is possible that the increase in indemnity costs seen in the present study may be due, in part to higher wages among older construction workers. Since age and type of injury explained only a small percentage of the variance in indemnity cost, there are likely to be several other, unexplained factors that contribute to costs that we were not able to account for. The present study likely underestimates the true frequency and cost due to potential underreporting of injuries that were covered by Social Security, unemployment insurance, disability coverage, Medicaid, and other private and public insurance systems [Dembe, 2001].

CONCLUSIONS

By the year 2018, the participation rate of workers over the age of 55 will have increased while the participation rate of workers between the ages of 16 and 54 will have decreased [Toossi, 2009]. Maintaining the employability of older workers will be critical in order to compensate for the decreasing labor force participation rates of those in their prime working years. In physically demanding industries like construction, the impact of the aging population can be significant. The physical limitations that older construction workers experience [Dong et al., 2011] may limit older workers ability to perform physically demanding tasks in the construction industry without becoming injured [Schwatka et al., 2012]. Older construction workers may be more likely to hold supervisorial positions due to experience and tenure, and thus may not have the same exposures to illness- and injury-related risk factors than younger workers. However, as the number of skilled construction workers in the labor force decrease, there may be an increased demand for older workers to remain in more laborious positions [U.S. Bureau of Labor Statistics, 2012]. Thus, subsequent efforts to return to work after injury or illness may be hindered by the difficultly to make accommodations in the construction industry [Berecki-Gisolf et al., 2012].

While this study indicated that older workers filed a small percentage of the total WC claims, the WC costs incurred by them were more costly on a per claim basis than their younger counterparts for indemnity rather than medical costs. This study illustrates the economic significance of injuries and illnesses among older construction workers. Additional research is needed to determine if older construction workers are selectively reporting inju-ries, which would likely have an effect on the medical and indemnity costs. The utilization of WC cost data is a useful but lagging indicator of the state of occupational health and safety among construction workers. New research should be aimed at leading indicators (e.g., safety climate/culture) of health and safety that promote the development of proactive injury prevention strategies. Leading indicators have the potential to identify the risk of occupational injuries prior to their occurrence among construction workers of all ages.

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REFERENCES

Arndt V, Rothenbacher D, Daniel U, Zschenderlein B, Schuberth S, Brenner H. Construction work and risk of occupational disability: A ten year follow up of 14 474 male workers. Occup Environ Med. 2005; 62:559–566. [PubMed: 16046609]

Berecki-Gisolf J, Clay FJ, Collie A, McClure RJ. The impact of aging on work disability and return to work insights from workers' compensation claim records. J Occup Environ Med. 2012; 54:318–327. [PubMed: 22371057]

Center for Construction Research and Training. The construction chart book: The U.S. construction industry and its workers. 4th. Silver Spring, MD: 2008.

Chairman of the Council of Economic Advisors: United States Government Printing Office. Economic report of the president. 2012. Retrieved on March 2012 from http://www.gpo.gov/fdsys/pkg/ERP-2012/pdf/ERP-2012-table60.pdf

Choi SD. Safety and ergonomic considerations for an aging workforce in the US construction industry. Work. 2009; 33:301–315.

Courtney TK, Matz S, Webster BS. Disabling occupational injury in the US construction industry, 1996. J Occup Environ Med. 2002; 44:1161–1168. [PubMed: 12500458]

de Zwart BCH, Frings-Dresen MHW, van Duivenbooden JC. Senior workers in the Dutch construction industry: A search for age-related work and health issues. Exp Aging Res. 1999; 25:385–391. [PubMed: 10553521]

Dembe AE. The social consequences of occupational injuries and illnesses. Am J Ind Med. 2001; 40:403–417. [PubMed: 11598991]

Dong X, Wang X, Daw C, Ringen K. Chronic diseases and functional limitations among older construction workers in the Unit-ed States: A 10 year follow-up study. J Occup Environ Med. 2011; 53:372–380. [PubMed: 21407096]

Dong XW, Ringen K, Men YR, Fujimoto A. Medical costs and sources of payment for work-related injuries among Hispanic construction workers. J Occup Environ Med. 2007; 49:1367–1375. [PubMed: 18231083]

Douphrate DI, Rosecrance JC, Reynolds SJ, Stallones L, Gilkey DP. Tractor-related injuries: An analysis of workers' compensa-tion data. J Agromed. 2009a; 14:198–205.

Douphrate DI, Rosecrance JC, Stallones L, Reynolds SJ, Gilkey DP. Livestock-handling injuries in agriculture: An analysis of Colorado workers' compensation data. Am J Ind Med. 2009b; 52:391–407. [PubMed: 19197949]

Douphrate DI, Rosecrance JC, Wahl G. Workers' compensa-tion experience of Colorado agriculture workers, 2000–2004. Am J Ind Med. 2006; 49:900–910. [PubMed: 17036351]

Friedman L, Forst L. Workers' compensation costs among construction workers: A robust regression analysis. J Occup Environ Med. 2009; 51:1306–1313. [PubMed: 19749601]

Hofmann J, Snyder K, Keifer M. A descriptive study of workers' compensation claims in Washington State orchards. Occup Med (Lond). 2006; 56:251–257. [PubMed: 16627546]

Hoonakker P, van Duivenbooden C. Monitoring working conditions and health of older workers in Dutch construction industry. Am J Ind Med. 2010; 53:641–653. [PubMed: 20506462]

Horwitz IB, McCall BP. Disabling and fatal occupational claim rates, risks, and costs in the Oregon construction industry 1990–1997. J Occup Environ Hyg. 2004; 1:688–698. [PubMed: 15631060]

Kucera KL, Lipscomb HJ, Silverstein B, Cameron W. Predictors of delayed return to work after back injury: A case-control analysis of union carpenters in Washington State. Am J Ind Med. 2009; 52:821–830. [PubMed: 19731240]

Lipscomb H, Cameron W, Silverstein B. Incident and recurrent back injuries among union carpenters. Occup Environ Med. 2008; 65:827–834. [PubMed: 18611968]

Lipscomb H, Leiming L, Dement JM. Falls among union carpenters. Am J Ind Med. 2003; 44:148–156. [PubMed: 12874847]

Lipscomb HJ, Dement JM, Silverstein B, Cameron W, Glazner JE. Compensation costs of work-related back disorders among union carpenters, Washington State 1989–2003. Am J Ind Med. 2009; 52:587–595. [PubMed: 19533677]

Lowery JT, Borgerding JA, Zhen B, Glazner JE, Bondy J, Kreiss K. Risk factors for injury among construction workers at Denver International Airport. Am J Ind Med. 1998; 34:113–120. [PubMed: 9651620]

Maertens, JA.; Putter, SE.; Chen, PY.; Diehl, M.; Huang, E. Physical capabilities and occupational health of older workers. In: Hedge, JW.; Borman, WC., editors. Oxford handbook of work and aging. Oxford University Press; New York: 2012.

NORA Construction Sector Council. National Occupational Research Agenda—National Construction Agdenda. 2008. Retrieved on 2011 from http://www.cdc.gov/niosh/nora/comment/agendas/construction/?

Restrepo, T.; Shuford, H. Workers' compensation and the aging workforce. 2011. National Council on Compensation Insurance Research Brief. NCCI Holdings, INC. Retrieved on January 2012 from https://www.ncci.com/nccimain/IndustryInformation/ResearchOutlook/Pages/NCCIResearch-AgingWorkforce-WC.aspx

Rogers E, Wiatrowski WJ. Injuries, illnesses and fatalities among older workers. Monthly Labor Rev. 2005; 128:24–30.

Schoenfisch AL, Lipscomb HJ, Shishlov K, Myers DJ. Nonfatal construction industry-related injuries treated in hospital emergency departments in the United States, 1998–2005. Am J Ind Med. 2010; 53:570–580. [PubMed: 20506460]

Schwatka NV, Butler LM, Rosecrance JC. An aging workforce and injury in the construction industry. Epidemiol Rev. 2012; 34:156–167. [PubMed: 22173940]

Statistics of U.S. Businesses. Historcal tabulations by enterprise size. 1998–2008. Retrieved on March 2012 from http://www.census.gov/econ/susb/historical≥data.html

Toossi M. Labor force projections to 2018: Older workers staying more active. Monthly Labor Rev. 2009; 132:30–51.

U.S. Bureau of Labor Statistics. Industry injury and illness data. 2009. Retrieved on May 2011 from http://bls.gov/iif/oshsum.htm

U.S. Bureau of Labor Statistics. Employer costs for employee compensation. 2011. Retrieved on March 2011 from http://www.bls.gov/ncs/ect/

U.S. Bureau of Labor Statistics. Occupational Outlook Hand-book. 2012. Retrieved on March 2012 from http://bls.gov/ooh/construction-and-extraction/home.htm

Waehrer G, Dong X, Miller T, Haile E, Men Y. Costs of occupational injuries in construction in the United States. Accid Anal Prev. 2007a; 39:1258–1266. [PubMed: 17920850]

Waehrer GM, Dong XS, Miller T, Men Y, Haile E. Occupational injury costs and alternative employment in construction trades. J Occup Environ Med. 2007b; 49:1218–1227. [PubMed: 17993926]

Welch L, Haile E, Boden L, Hunting K. Age, work limitatins and physical functioning among construction roofers. Work. 2008; 31:377–385. [PubMed: 19127008]

Welch L, Haile E, Boden LI, Hunting KL. Impact of musculo-skeletal and medical conditions on disability retirement—A longitu-dinal study among construction workers. Am J Ind Med. 2010; 53:552–560. [PubMed: 20112256]

FIGURE 1.
Timeline of claim filling.

TABLE I

Inflation-Adjusted Mean and Median Workers' Compensation Costs by Claimant Age and Cost Type

		Age group					
	Total	**18–24 (n = 21,733)**	**25–34 (n = 36,018)**	**35–44 (n = 27,092)**	**45–54 (n = 16,360)**	**55–64 (n = 5,259)**	**65+ (n = 603)**
Type of cost							
Total ($)							
Mean	8,432	4,899	7,439	10,320	12,176	13,194	14,253
(SD)	(37,637)	(31,935)	(34,063)	(39,287)	(48,943)	(44,404)	(37,170)
Median	563	474	544	642	706	775	861
IQR	280–2,022	254–1,143	285–1,671	296–3,059	305–4,707	308–5,464	295–7,056
Medical ($)							
Mean	3,709	2,424	3,284	4,207	5,551	5,632	5,275
(SD)	(20,672)	(14,026)	(16,665)	(17,387)	(35,944)	(25,971)	(14,291)
Median	521	450	507	582	631	674	718
IQR	261–1,450	240–963	267–1,275	274–1,897	278–2,630	279–2,837	268–3,054
Indemnity ($)							
Mean	4,306	2,168	3,661	5,402	5,819	6,762	8,142
(SD)	(21,676)	(20,295)	(20,710)	(24,075)	(19,851)	(24,386)	(25,809)
Median	0	0	0	0	0	0	0
IQR	0–0	0–0	0–0	0–157	0–690	0–1,004	0–2,380

SD, standard deviation; IQR, inter-quartile range.

Costs ($) adjusted for inflation to2010 dollars.n = number of claims.

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TABLE II

Inflation-Adjusted Mean and MedianWorkers' Compensation Costs by Claimant Age,Cost Type, and Type of Injury

		Age group					
	Total	**18–24 (n = 21,733)**	**25–34 (n = 36,018)**	**35–44 (n = 27,092)**	**45–54 (n = 16,360)**	**55–64 (n = 5,259)**	**65+ (n = 603)**
Type of injury							
Strain							
Total (n), percent (%)of claims	28,855 (26%)	4,437 (20%)	9,501 (26%)	8,115 (30%)	5,052 (31%)	1,594 (30%)	156 (26%)
Total cost ($), mean	10,917	5,385	9,464	13,428	14,392	15,373	11,834
(SD)	(30,795)	(17,180)	(20,020)	(33,194)	(41,146)	(38,150)	(24,742)
Median	384	577	750	965	1,147	1,149	976
IQR	289–430	281–1,732	326–2,083	328–6,329	344–9123	339–9,599	381–11,439
Medical cost ($), mean	4,083	2,103	3,365	4,714	5,629	5,750	4,143
(SD)	(14,846)	(6,518)	(9,755)	(15,529)	(26,819)	(13,977)	(6,662)
Median	694	504	642	795	913	929	879
IQR	287–2,360	256–1,256	291–1,834	294–3,064	304–4,096	289–4,531	349–4,612
Indemnity cost($), mean	6,253	2,840	2,840	5,379	7,734	8,671	7,008
(SD)	(19,089)	(5,417)	(11,289)	(16,834)	(22,170)	(25,517)	(18,982)
Median	0	0	0	0	0	0	0
IQR	0–909	0–0	0–0	0–420	0–1,687	0–2,872	0–3,888
Contusion							
Total (n), percent (%)of claims	22,406 (21%)	4,608 (21%)	7,231 (20%)	5,646 (21%)	3,542 (22%)	1,215 (23%)	164 (27%)
Total cost ($), mean	8,463	4,803	7,638	10,578	11,608	11,979	17,208
(SD)	(41,753)	(36,871)	(39,012)	(52,774)	(38,649)	(38,075)	(41,308)
Median	549	456	539	612	640	712	893
IQR	269–1,882	246–1,081	278–1,704	282–2,630	300–3,645	276–3,566	324–6,411
Medical cost ($), mean	3,829	2,371	3,482	4,251	5,295	4,858	6,133
(SD)	(19,617)	(17,725)	(21,406)	(18,372)	(21,217)	(15,930)	(15,219)
Median	515	434	501	559	593	644	729
IQR	255–1,453	230–940	259–1,307	259–1,737	281–2,391	266–2,461	292–3,181
Indemnity cost($), mean	4,294	2,116	3,645	5,536	5,496	6,350	10,201
(SD)	(25,641)	(22,150)	(21,125)	(32,118)	(19,469)	(24,627)	(30,770)
Median	0	0	0	0	0	0	0
IQR	0–0	0–0	0–0	0–0	0–220	0–255	0–2,691
Laceration							
Total (n), percent (%) of claims	17,451 (17%)	4,455 (21%)	6,331 (18%)	3,987 (14%)	1,977 (12%)	628 (12%)	70 (12%)
Total cost ($), mean	2,670	2,160	2,588	3,281	3,323	3,731	1,281
(SD)	(13,757)	(9,177)	(15,025)	(15,127)	(17,100)	(15,645)	(3,047)
Median	473	453	467	488	515	507	516

	Total	Age group 18–24 (n = 21,733)	25–34 (n = 36,018)	35–44 (n = 27,092)	45–54 (n = 16,360)	55–64 (n = 5,259)	65+ (n = 603)
IQR	289–844	273–806	295–825	294–923	310–944	309–936	289–1,011
Medical cost ($), mean	1,622	1,404	1,504	1,802	2,030	2,011	856
(SD)	(6,188)	(4,565)	(5,621)	(7,176)	(8,572)	(6,158)	(1,384)
Median	465	446	458	480	508	501	514
IQR	283–813	262–765	289–786	285–874	302–866	304–898	289–988
Indemnity cost($), mean	998	664	961	1,289	1,164	1,450	401
(SD)	(8,250)	(4,826)	(9,999)	(8,035)	(8,644)	(8,420)	(1,760)
Median	0	0	0	0	0	0	0
IQR	0–0	0–0	0–0	0–0	0–0	0–0	0–0
Other[a]							
Total (n), percent (%)of claims	38,350 (36%)	8,232 (38%)	12,951 (36%)	9,343 (35%)	5,789 (35%)	1,822 (35%)	213 (35%)
Total cost ($), mean	9,227	6,175	8,215	10,470	13,614	15,359	18,013
(SD)	(40,033)	(41,489)	(41,894)	(41,337)	(65,161)	(57,693)	(45,606)
Median	532	461	509	613	659	802	988
IQR	262–2,101	239–1,182	259–1,656	284–3,364	283–5,533	301–7,520	235–11,349
Medical cost ($), mean	4,607	2,765	3,984	4,766	6,41	7,292	6,897
(SD)	(28,723)	(17,556)	(20,718)	(22,613)	(52,130)	(39,833)	(19,514)
Median	503	441	479	552	590	687	795
IQR	245–1,521	225–986	246–1,267	262–1,943	256–2,904	275–3,234	126–4,334
Indemnity cost($), mean	4,351	2,649	3,732	5,052	5,942	7,198	9,930
(SD)	(24,790)	(27,014)	(26,099)	(21,659)	(22,063)	(56,562)	(29,527)
Median	0	0	0	0	0	0	0
IQR	0–0	0–0	0–0	0–176	0–912	0–1,863	0–4,355

SD, standard deviation; IQR, inter-quartile range.

Costs ($) adjusted for inflation to 2010 dollars.N = number of claims.

[a]The “other” injury types include: burn, crushing,foreign body, fracture, puncture, sprain, and all other.

TABLE III

ANOVA Multiple Comparison of *P*-Values for Differences in Mean Costs by Claimant Age and Cost Type

	Age group					
	18–24	**25–34**	**35–44**	**45–54**	**55–64**	**65+**
18–24						
Total		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Medical		<0.0001	<0.0001	<0.0001	<0.0001	0.0038
Indemnity		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
25–34						
Total			<0.0001	<0.0001	<0.0001	<0.0001
Medical			<0.0001	<0.0001	<0.0001	***0.6643***
Indemnity			<0.0001	<0.0001	<0.0001	<0.0001
35–44						
Total				***0.0218***	***0.0159***	***0.3318***
Medical				***0.4869***	***0.4262***	***1.000***
Indemnity				<0.0001	<0.0001	<0.0001
45–54						
Total					***1.000***	***1.000***
Medical					***1.000***	***1.000***
Indemnity					***1.000***	***0.0140***
55–64						
Total						***1.000***
Medical						***1.000***
Indemnity						***0.1038***
65+						
Total						
Medical						
Indemnity						

A Bonferroni adjustment method was used (0.05/15 = 0.003). Mean total cost and medical cost by age group are significantly different up until the age group 35–44. However, mean indemnity costs are significantly different up until the age group 45–54.

TABLE IV

Individual Linear Regression Models for Age (Years and Categorical)ofClaimant and Cost of a Claim by Cost Type

Outcome	β [a]	95%CI [a]	Percent(%)increase [d]	% of variance explained by age
Total cost [b,c]				
Age continuous	1.017	1.016,1.019	1.7	0.58
Age groups				
18–24	Reference			
25–34	1.267	1.21, 1.32	26.7	0.04
35–44	1.582	1.51,1.66	58.2	0.07
45–54	1.719	1.63,1.81	71.9	0.24
55–64	1.801	1.66,1.95	80.1	0.20
65+	2.026	1.63, 2.50	102.6	0.04
Medical cost [b,c]				
Age continuous	1.011	1.010,1.013	1.1	0.27
Age groups				
18–24	Reference			
25–34	1.187	1.14,1.24	18.7	0.01
35–44	1.353	1.30, 1.41	35.3	0.04
45–54	1.428	1.36,1.50	42.8	0.12
55–64	1.470	1.36,1.60	47.0	0.09
65+	1.460	1.19,1.79	46.0	0.01
Indemnity cost [b,c]				
Age continuous	1.036	1.033,1.037	3.6	1.12
Age groups				
18–24	Reference			
25–34	1.419	1.33,1.51	41.9	0.14
35–44	2.240	2.10, 2.39	124.0	0.08
45–54	2.843	2.63,3.06	184.4	0.44
55–64	3.074	2.75,3.43	207.4	0.34
65+	4.716	3.50,6.36	372.0	0.10

Costs ($) adjusted for inflation to 2010 dollars and log-transformed. CI = confidence interval.

[a]Estimatesand corresponding 95% CI's have been back transformed (i.e., exp(beta)).

[b]Models with age as a continuous variable and a categorical variable were run separately.

[c]Outcome variables were log transformed.

[d]Percent (%) increase in the cost of a claim for each year increase in age or compared to the age group 18–24, depending on how age was imputed in the model. Percent (%) increase = {[exp(beta)] – 1} × 100.

TABLE V

Linear Regression Models for Type of Injury and Indemnity Cost of a Claim by Age of Claimant

			Interaction model β (95% CI)[a,b]					
			Age groups					
Injury type	**β (95%CI)[a]**	**Age adjusted β(95%CI)[a]**	**18–24**	**25–34**	**35–44**	**45–54**	**55–64**	**65+**
Strain	1.00 (—)	1.00 (—)	1.00 (—)	1.70 (1.48,1.92)	2.67 (2.33,3.04)	3.32 (2.86,3.84)	3.42 (2.77,4.21)	3.61 (2.02,6.50)
Contusion	0.46 (0.43,0.49)	0.48 (0.45,0.51)	1.00 (—)	1.51 (1.32,1.73)	2.34 (2.30,3.70)	2.78 (2.37,3.26)	2.86 (2.27,3.61)	6.53 (3.70,11.53)
Laceration	0.19 (0.17,0.20)	0.20 (0.190,0.22)	1.00 (—)	0.94 (0.82,1.09)	1.12 (0.96,1.31)	1.12 (0.92,1.36)	1.03 (0.76,1.40)	0.826 (0.35,1.96)
Other[c]	0.53 (0.50,0.56)	0.56 (0.53,0.59)	1.00 (—)	1.31 (1.18,1.38)	2.04 (1.84,2.78)	2.69 (2.38,3.04)	3.35 (2.78,4.04)	6.69 (4.07,11.00)
r^2	0.021	0.029	0.031					

Costs ($) adjusted for inflation to 2010 dollars and log-transformed. CI = confidence interval.

[a]Estimates and corresponding 95% CI's have been back transformed (i.e., exp(beta)).

[b]The interaction model betas represent a no intercept model where each estimate is considered the change in cost of a claim for type of injury by age group. For example, claimants ≥ 65 years have a 261 % higher indemnity cost of a claim than claimants aged 18–24 for a strain type of injury. Percent (%) increase = {[exp(beta)] – 1} × 100.

[c]The "other" injury types include: burn, crushing, foreign body,fracture, puncture, sprain, and all other.